

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents
 United States Patent and Trademark
 Office
 Box PCT
 Washington, D.C.20231
 ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 08 June 2000 (08.06.00)	
International application No. PCT/SE99/01884	Applicant's or agent's file reference PC-2008184
International filing date (day/month/year) 19 October 1999 (19.10.99)	Priority date (day/month/year) 22 October 1998 (22.10.98)
Applicant CLAESSON, Ingvar et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

17 May 2000 (17.05.00)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer C. Villet Telephone No.: (41-22) 338.83.38
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14

Applicant's or agent's file reference PC-2008184	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/SE99/01884	International filing date (day month year) 19.10.1999	Priority date (day month year) 22.10.1998
International Patent Classification (IPC) or national classification and IPC7 B23B 29/12, F16F 15/00		
Applicant Claesson, Ingvar et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 3 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 17.05.2000	Date of completion of this report 16.02.2001
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88	Authorized officer Joakim Movander/LR Telephone No. 08-782 25 00

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE99/01884

I. Basis of the report

1. With regard to the elements of the international application:*

- ☐ the international application as originally filed
- ☒ the description:
pages 1-7, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☒ the claims:
pages _____, as originally filed
pages _____, as amended (together with any statement) under article 19
pages _____, filed with the demand
pages 8-10, filed with the letter of 22.11.2000
- ☒ the drawings:
pages 1-2, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the sequence listing part of the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language _____ which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE99/01884

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	<u>1-15</u>	YES
	Claims		NO
Inventive step (IS)	Claims	<u>1-15</u>	YES
	Claims		NO
Industrial applicability (IA)	Claims	<u>1-15</u>	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The claimed invention relates to a method and device for controlling a turning operation. The invention is intended to solve the problem of providing a method and device, which reduces unevenness in the turned surface. The solution according to the claimed invention comprises a control unit and an actuator connected to the control unit and a tool holder. The actuator is adapted to impart a vibration motion in the lateral direction, wherein the tool holder is made to move alternately in and against the direction of feed and thereby simulating a larger nose radius of the cutting edge of a working tool.

In their letter of 2000-11-16, the applicant has amended the original claim 1, 4, 8 and 12 to now state that the tool holder is made to move in a vibration manner alternately in and against the direction of feed when the device is mounted in the turning lathe.

The document US, A, 5 170 103 shows a device for active vibration control comprising a control unit (102) and an actuator (64), connected to the control unit (102) and embedded in a tool holder (12). A sensor (92) detects vibration movement and the actuator (64) generates counter vibration in order to dampen the detected vibration movement.

The document US, A, 4 849 668 shows an active vibration damping system comprising a control unit (12) and two actuators (22, 24), connected to the control unit (12) and embedded in a beam (20). The two actuators are arranged on opposite side of the centre axis of the beam (20), see figure 4.

The documents JP, A, 63180401 and US, A, 5 558 477 also show devices for active vibration control comprising control units

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE99/01884

Supplemental Box

(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: V

and embedded in tool holders, similar to the device described in document US, A, 5 170 103.

However, none of these documents disclose a device for increasing the surface smoothness of a turning surface by simulating a larger nose radius of the cutting edge of the working tool. According to the invention, this simulation is performed by imparting a lateral vibrating motion to the tool holder and thereby causing it to vibrate even more in the direction of feed.

According to the arguments stated above, the invention described in claims 1-15 is novel, has an inventive step and is industrially applicable.

CLAIMS

1. A device for increasing the surface smoothness
5 of a turned surface, said device comprising a control
system comprising a control unit (7) and an actuator (9,
11) connectible to the control unit and connectible with
a tool holder (5), c h a r a c t e r i s e d in that said
10 actuator is adapted to impart a vibrating motion in the
lateral direction to the tool holder, wherein the tool
holder is made to move in a vibrating manner
alternatingly in and against the direction of feed when
the device is mounted in a turning lathe.

2. A device as claimed in claim 1, c h a r a c -
15 t e r i s e d in that said actuator (9, 11) comprises an
active element (9, 11) which is embeddable in the body of
the tool holder (5).

3. A device as claimed in claim 1 or 2, c h a r -
a c t e r i s e d in that the control system comprises a
20 vibration sensor (13, 15) connectible to the control unit
(7) and connectible with the tool holder (5), that said
vibration sensor is adapted to detect vibrations of the
tool holder in the lateral direction, and that the con-
trol unit is adapted to control the vibrating motion by
25 controlling the actuator according to sensor signals from
the vibration sensor.

4. A turning tool holder, c h a r a c t e r i s e d
in that it comprises an actuator (9, 11) which is adapted
to impart a vibrating motion in the lateral direction to
30 the turning tool holder (5), wherein the turning tool
holder is made to move in a vibrating manner
alternatingly in and against the direction of feed when
the device is mounted in a turning lathe.

5. A turning tool holder as claimed in claim 4,
35 c h a r a c t e r i s e d in that said actuator (9, 11)
comprises an active element (9, 11) which is embedded in
the body of the turning tool holder (5).

6. A turning tool holder as claimed in claim 4 or 5, characterised in that it comprises at least one pair of active elements, the active elements included in the pair being oppositely arranged on each side of the centre axis of the turning tool holder (5).

7. A turning tool holder as claimed in claim 4, 5 or 6, characterised in that it comprises a vibration sensor (13, 15) which is embedded in the body of the turning tool holder (5).

8. A turning lathe comprising a tool holder (5) and an actuator (9, 11) connected with the tool holder, characterised in that the actuator is adapted to impart a vibrating motion in the lateral direction to the tool holder, in order to make the tool holder move in a vibrating manner alternately in and against the direction of feed.

9. A turning lathe as claimed in claim 8, characterised in that it comprises a control system, the control system comprising a control unit (7) and a vibration sensor (13, 15) connected to the control unit and connected with the tool holder, that said actuator is connected to the control unit, that said vibration sensor is adapted to detect the vibrations of the tool in the lateral direction, and that the control unit is adapted to control the vibrating motion by controlling the actuator according to sensor signals from the vibration sensor.

10. A turning lathe as claimed in claim 8 or 9, characterised in that said actuator (9, 11) comprises an active element (9, 11) which is embedded in the body of the tool holder (5).

11. A turning lathe as claimed in claim 10, characterised in that said active element (9, 11) is a piezoceramic element (9, 11).

12. A method for increasing the surface smoothness of a turned surface, comprising the step of controlling the vibrations of a tool holder during turning,

characterised by the step of imparting a vibrating motion in the lateral direction to the tool holder, in order to make the tool holder move in a vibrating manner alternately in and against the
5 direction of feed.

13. A method as claimed in claim 12, characterised by the step of imparting to the tool holder said vibrating motion by means of an actuator comprising an active element embedded in the body of the tool
10 holder.

14. A method as claimed in claim 13, characterised by the step of controlling in a fed-back manner said vibrating motion by detecting the lateral vibration of the tool holder and controlling said actuator according to said lateral vibration.
15

15. A method as claimed in any one of claims 12-14, characterised by the step of adjusting said vibrating motion to the feeding speed.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference PC-2008184	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/SE99/01884	International filing date (day month year) 19.10.1999	Priority date (day month year) 22.10.1998
International Patent Classification (IPC) or national classification and IPC7 B23B 29/12, F16F 15/00		
Applicant Claesson, Ingvar et al.		

<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of <u>4</u> sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of <u>3</u> sheets.</p>
<p>3. This report contains indications relating to the following items:</p> <p>I <input checked="" type="checkbox"/> Basis of the report</p> <p>II <input type="checkbox"/> Priority</p> <p>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p>IV <input type="checkbox"/> Lack of unity of invention</p> <p>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p>VI <input type="checkbox"/> Certain documents cited</p> <p>VII <input type="checkbox"/> Certain defects in the international application</p> <p>VIII <input type="checkbox"/> Certain observations on the international application</p>

Date of submission of the demand 17.05.2000	Date of completion of this report 16.02.2001
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88	Authorized officer Joakim Movander/LR Telephone No. 08-782 25 00

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE99/01884

I. Basis of the report**1. With regard to the elements of the international application:***

- ☐ the international application as originally filed
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pages 1-7, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☒ the claims:
pages _____, as originally filed
pages _____, as amended (together with any statement) under article 19
pages _____, filed with the demand
pages 8-10, filed with the letter of 22.11.2000
- ☒ the drawings:
pages 1-2, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the sequence listing part of the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

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- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
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- ☐ the description, pages _____
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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE99/01884

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**1. Statement**

Novelty (N)	Claims	<u>1-15</u>	YES
	Claims		NO
Inventive step (IS)	Claims	<u>1-15</u>	YES
	Claims		NO
Industrial applicability (IA)	Claims	<u>1-15</u>	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The claimed invention relates to a method and device for controlling a turning operation. The invention is intended to solve the problem of providing a method and device, which reduces unevenness in the turned surface. The solution according to the claimed invention comprises a control unit and an actuator connected to the control unit and a tool holder. The actuator is adapted to impart a vibration motion in the lateral direction, wherein the tool holder is made to move alternately in and against the direction of feed and thereby simulating a larger nose radius of the cutting edge of a working tool.

In their letter of 2000-11-16, the applicant has amended the original claim 1, 4, 8 and 12 to now state that the tool holder is made to move in a vibration manner alternately in and against the direction of feed when the device is mounted in the turning lathe.

The document US, A, 5 170 103 shows a device for active vibration control comprising a control unit (102) and an actuator (64), connected to the control unit (102) and embedded in a tool holder (12). A sensor (92) detects vibration movement and the actuator (64) generates counter vibration in order to dampen the detected vibration movement.

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The documents JP, A, 63180401 and US, A, 5 558 477 also show devices for active vibration control comprising control units

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE99/01884

Supplemental Box

(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: V

and embedded in tool holders, similar to the device described in document US, A, 5 170 103.

However, none of these documents disclose a device for increasing the surface smoothness of a turning surface by simulating a larger nose radius of the cutting edge of the working tool. According to the invention, this simulation is performed by imparting a lateral vibrating motion to the tool holder and thereby causing it to vibrate even more in the direction of feed.

According to the arguments stated above, the invention described in claims 1-15 is novel, has an inventive step and is industrially applicable.

CLAIMS

1. A device for increasing the surface smoothness
5 of a turned surface, said device comprising a control
system comprising a control unit (7) and an actuator (9,
11) connectible to the control unit and connectible with
a tool holder (5), c h a r a c t e r i s e d in that said
actuator is adapted to impart a vibrating motion in the
10 lateral direction to the tool holder.

2. A device as claimed in claim 1, c h a r a c -
t e r i s e d in that said actuator (9, 11) comprises an
active element (9, 11) which is embeddable in the body of
the tool holder (5).

15 3. A device as claimed in claim 1 or 2, c h a r -
a c t e r i s e d in that the control system comprises a
vibration sensor (13, 15) connectible to the control unit
(7) and connectible with the tool holder (5); that said
vibration sensor is adapted to detect vibrations of the
20 tool holder in the lateral direction, and that the con-
trol unit is adapted to control the vibrating motion by
controlling the actuator according to sensor signals from
the vibration sensor.

4. A turning tool holder, c h a r a c t e r i s e d (
25 in that it comprises an actuator (9, 11) which is adapted
to impart a vibrating motion in the lateral direction to
the turning tool holder (5). (

5. A turning tool holder as claimed in claim 4,
c h a r a c t e r i s e d in that said actuator (9, 11)
30 comprises an active element (9, 11) which is embedded in
the body of the turning tool holder (5).

6. A turning tool holder as claimed in claim 4 or 5,
c h a r a c t e r i s e d in that it comprises at least
one pair of active elements, the active elements included
35 in the pair being oppositely arranged on each side of the
centre axis of the turning tool holder (5).

7. A turning tool holder as claimed in claim 4, 5 or 6, characterised in that it comprises a vibration sensor (13, 15) which is embedded in the body of the turning tool holder (5).

5 8. A turning lathe comprising a tool holder (5) and an actuator (9, 11) connected with the tool holder, characterised in that the actuator is adapted to impart a vibrating motion in the lateral direction to the tool holder.

10 9. A turning lathe as claimed in claim 8, characterised in that it comprises a control system, the control system comprising a control unit (7) and a vibration sensor (13, 15) connected to the control unit and connected with the tool holder, that said actuator
15 is connected to the control unit, that said vibration sensor is adapted to detect the vibrations of the tool in the lateral direction, and that the control unit is adapted to control the vibrating motion by controlling the actuator according to sensor signals from the vibration sensor.
20

10. A turning lathe as claimed in claim 8 or 9, characterised in that said actuator (9, 11) comprises an active element (9, 11) which is embedded in the body of the tool holder (5).

25 11. A turning lathe as claimed in claim 10, characterised in that said active element (9, 11) is a piezoceramic element (9, 11).

12. A method for increasing the surface smoothness of a turned surface, comprising the step of controlling
30 the vibrations of a tool holder during turning, characterised by the step of imparting a vibrating motion in the lateral direction to the tool holder.

13. A method as claimed in claim 12, characterised
35 terised by the step of imparting to the tool holder said vibrating motion by means of an actuator comprising

an active element embedded in the body of the tool holder.

14. A method as claimed in claim 13, characterised by the step of controlling in a fed-back manner said vibrating motion by detecting the lateral vibration of the tool holder and controlling said actuator according to said lateral vibration.

15. A method as claimed in any one of claims 12-14, characterised by the step of adjusting said vibrating motion to the feeding speed.

RECORD COPY

PC
REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty

Receiving Office use only	
SE 99 / 0 1 8 8 4	
International Application No.	
International Filing Date	19 -10- 1999
The Swedish Patent Office PCT International Application	
Name of receiving Office and "PCT International Application"	
Applicant's or agent's file reference (if desired) (12 characters maximum)	PC-2008184

Box No. I TITLE OF INVENTION		
METHOD AND DEVICE FOR A TURNING OPERATION		
Box No. II APPLICANT		
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)	<input checked="" type="checkbox"/> This person is also inventor.	
CLAESSON, Ingvar Hällestadsvägen 59 S-240 20 DALBY Sweden	Telephone No.	
	Facsimile No.	
	Teleprinter No.	
State (that is, country) of nationality: Sweden	State (that is, country) of residence: Sweden	
This person is applicant for the purposes of: <input checked="" type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box		
Box No. III FURTHER APPLICANT(S) AND/OR FURTHER INVENTOR(S)		
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)	This person is:	
LAGÖ, Thomas Kristinedalsvägen 54 S-553 31 JÖNKÖPING Sweden	<input type="checkbox"/> applicant only <input checked="" type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)	
	State (that is, country) of nationality: Sweden	State (that is, country) of residence: Sweden
	This person is applicant for the purposes of: <input checked="" type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
<input checked="" type="checkbox"/> Further applicants and/or (further) inventors are indicated on a continuation sheet		
Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE		
The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: <input checked="" type="checkbox"/> agent <input type="checkbox"/> common representative		
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)	Telephone No.	
AWAPATENT AB Box 45086 SE-104 30 STOCKHOLM SWEDEN	+46 8 440 95 00	
	Facsimile No.	
	+46 8 440 95 50	
Teleprinter No.		
<input type="checkbox"/> Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent		

Continuation of Box No. III		OTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
<i>If none of the following sub-boxes is used, this sheet should not be included in the request</i>			
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) HÅKANSSON, Lars Norra Hagtorngatan 10 S-256 62 HELSINGBORG Sweden		This person is: <input type="checkbox"/> applicant only <input checked="" type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)	
State (that is, country) of nationality: Sweden		State (that is, country) of residence: Sweden	
This person is applicant for the purposes of: <input checked="" type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box			
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)		This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)	
State (that is, country) of nationality:		State (that is, country) of residence:	
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box			
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)		This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)	
State (that is, country) of nationality:		State (that is, country) of residence:	
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box			
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)		This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)	
State (that is, country) of nationality:		State (that is, country) of residence:	
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box			
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)		This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)	
State (that is, country) of nationality:		State (that is, country) of residence:	
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box			
<input type="checkbox"/> Further applicants and/or (further) inventors are indicated on another continuation sheet.			

Box No. V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

Regional Patent

- ☒ **AP** ARIPO Patent: GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA** Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP** European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA** OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

National Patent (if other kind of protection or treatment desired, specify on dotted line):

- | | | |
|---|--|--|
| <input checked="" type="checkbox"/> AE United Arab Emirates | <input checked="" type="checkbox"/> LR Liberia | |
| <input checked="" type="checkbox"/> AL Albania | <input checked="" type="checkbox"/> LS Lesotho | |
| <input checked="" type="checkbox"/> AM Armenia | <input checked="" type="checkbox"/> LT Lithuania | |
| <input checked="" type="checkbox"/> AT Austria +Utility Model | <input checked="" type="checkbox"/> LU Luxembourg | |
| <input checked="" type="checkbox"/> AU Australia | <input checked="" type="checkbox"/> LV Latvia | |
| <input checked="" type="checkbox"/> AZ Azerbaijan | <input checked="" type="checkbox"/> MD Republic of Moldova | |
| <input checked="" type="checkbox"/> BA Bosnia and Herzegovina | <input checked="" type="checkbox"/> MG Madagascar | |
| <input checked="" type="checkbox"/> BB Barbados | <input checked="" type="checkbox"/> MK The former Yugoslav Republic of Macedonia | |
| <input checked="" type="checkbox"/> BG Bulgaria | | |
| <input checked="" type="checkbox"/> BR Brazil | <input checked="" type="checkbox"/> MN Mongolia | |
| <input checked="" type="checkbox"/> BY Belarus | <input checked="" type="checkbox"/> MW Malawi | |
| <input checked="" type="checkbox"/> CA Canada | <input checked="" type="checkbox"/> MX Mexico | |
| <input checked="" type="checkbox"/> CH and LI Switzerland and Liechtenstein | <input checked="" type="checkbox"/> NO Norway | |
| <input checked="" type="checkbox"/> CN China | <input checked="" type="checkbox"/> NZ New Zealand | |
| <input checked="" type="checkbox"/> CU Cuba | <input checked="" type="checkbox"/> PL Poland | |
| <input checked="" type="checkbox"/> CZ Czech Republic +Utility Model | <input checked="" type="checkbox"/> PT Portugal | |
| <input checked="" type="checkbox"/> DE Germany +Utility Model | <input checked="" type="checkbox"/> RO Romania | |
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| <input checked="" type="checkbox"/> ES Spain | <input checked="" type="checkbox"/> SE Sweden | |
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| <input checked="" type="checkbox"/> GB United Kingdom | <input checked="" type="checkbox"/> SI Slovenia | |
| <input checked="" type="checkbox"/> GD Grenada | <input checked="" type="checkbox"/> SK Slovakia +Utility Model | |
| <input checked="" type="checkbox"/> GE Georgia | <input checked="" type="checkbox"/> SL Sierra Leone | |
| <input checked="" type="checkbox"/> GH Ghana | <input checked="" type="checkbox"/> TJ Tajikistan | |
| <input checked="" type="checkbox"/> GM Gambia | <input checked="" type="checkbox"/> TM Turkmenistan | |
| <input checked="" type="checkbox"/> HR Croatia | <input checked="" type="checkbox"/> TR Turkey | |
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| <input checked="" type="checkbox"/> KP Democratic People's Republic of Korea | <input checked="" type="checkbox"/> ZA South Africa | |
| | <input checked="" type="checkbox"/> ZW Zimbabwe | |
| <input checked="" type="checkbox"/> KR Republic of Korea | Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet: | |
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| <input checked="" type="checkbox"/> LC Saint Lucia | <input checked="" type="checkbox"/> DM Dominica | <input checked="" type="checkbox"/> MA Morocco |
| <input checked="" type="checkbox"/> LK Sri Lanka | | |

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)

Box No. VI		PRIORITY CLAIM		
Filing date of earlier application (day/month/year)	Number of earlier application	<input type="checkbox"/> Further priority claims indicated in the Supplement Box.		
		Where earlier application is:		
		national application: country	regional application: regional Office	international application: receiving Office
item (1) 22/10/98 22 October 1998	9803606-4	Sweden		
item (2)				
item (3)				



The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): 1

* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA)
(If two or more International Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):

ISA / SE

Request to use results of earlier search; reference to that search

(if an earlier search has been carried out by or requested from the International Searching Authority):

Date (day/month/year)

Number

Country (or regional Office)

26/04/1999

SE 99/00004

SE

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following number of sheets:

request : 4 ✓
description (excluding sequence listing part) : 7 ✓
claims : 3 ✓
abstract : 1 ✓
drawings : 2 ✓
sequence listing part of description :

Total number of sheets : 17 ✓

Figure of the drawings which should accompany the abstract: 1

This international application is accompanied by the item(s) marked below:

- ☒ fee calculation sheet
- ☐ separate signed power of attorney
- ☐ copy of general power of attorney; reference No., if any:
- ☐ statement explaining lack of signature
- ☐ priority document(s) identified in Box No. VI as item(s):
- ☐ translation of international applications into (language):
- ☐ separate indications concerning deposited microorganism or other biological material
- ☐ nucleotide and/or amino acid sequence listing in computer readable form
- ☒ other (specify): Copy of ITS Report, Sub-aut. GF 177/99

Language of filing of the international application:

Swedish

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

AWAPATENT AB



Steve Athle

Autorised Representative

1. Date of actual receipt of the Purported international application: 19-10-1999		2. Drawings: <input checked="" type="checkbox"/> received: <input type="checkbox"/> not received:
3. Corrected date of actual receipt due to later but Timely received papers or drawings completing the purported international application:		
4. Date of timely receipt of the required Corrections under PCT Article 11(2):		
5. International Searching Authority (if two or more are competent): ISA/ SE	6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid.	

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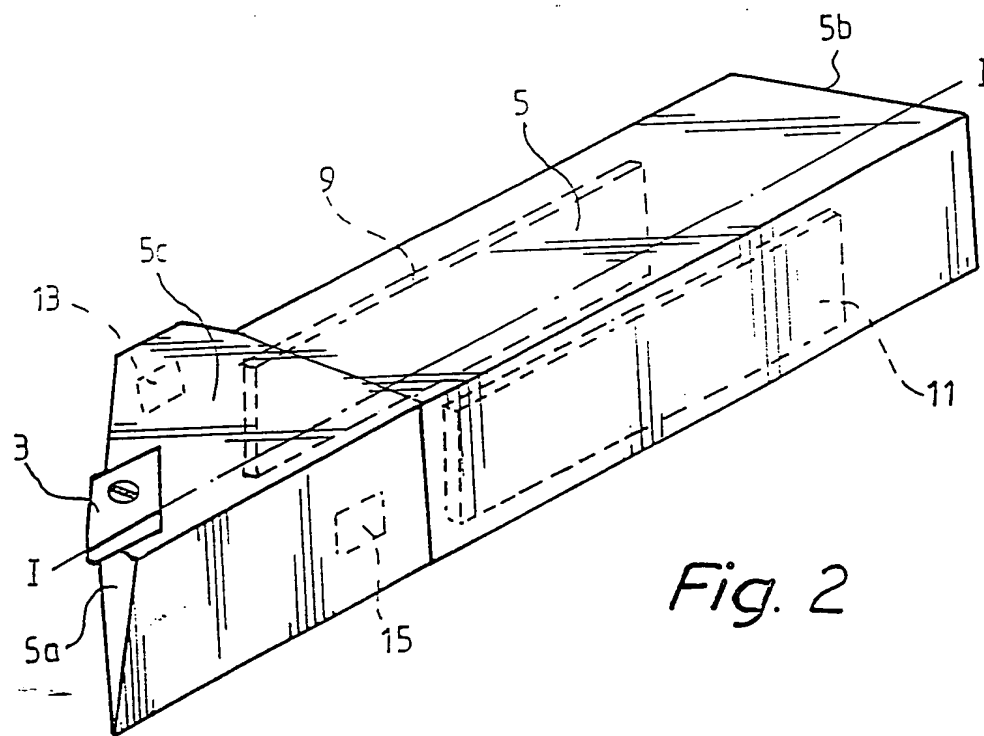
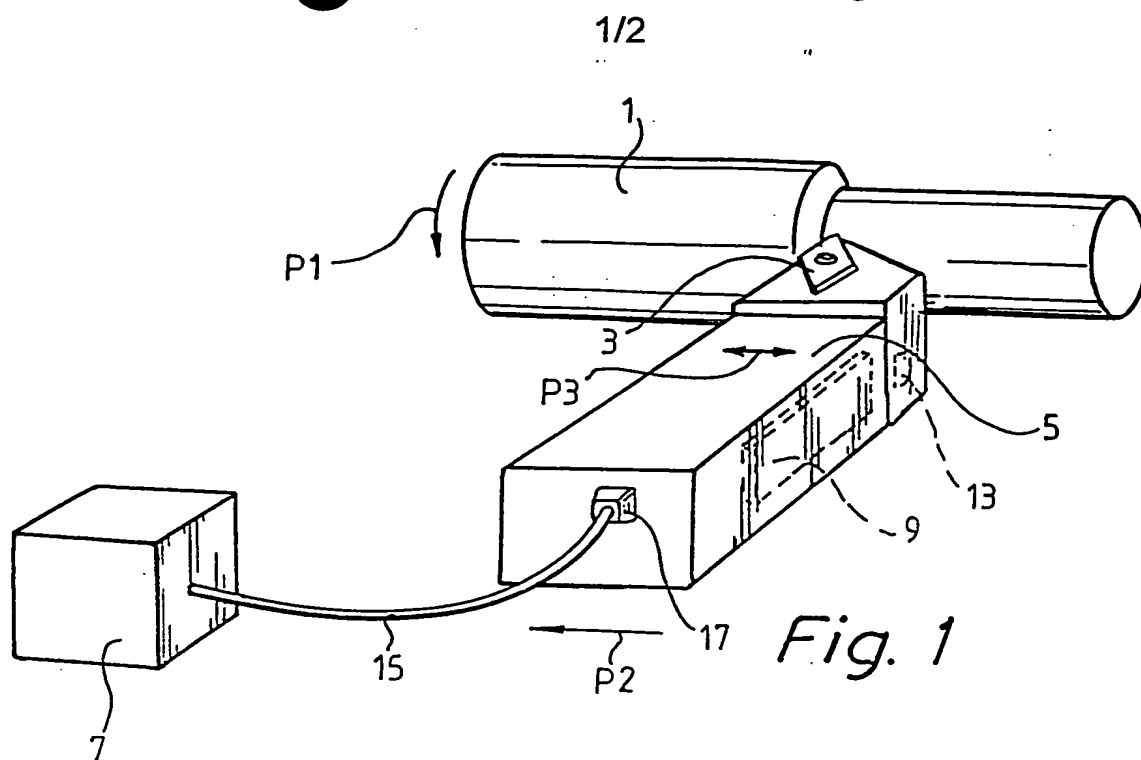
Date of receipt of the record copy by the International Bureau:

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(13.12.99)

Form PCT/RO/101 (last sheet) (July 1998; reprint July 1999)

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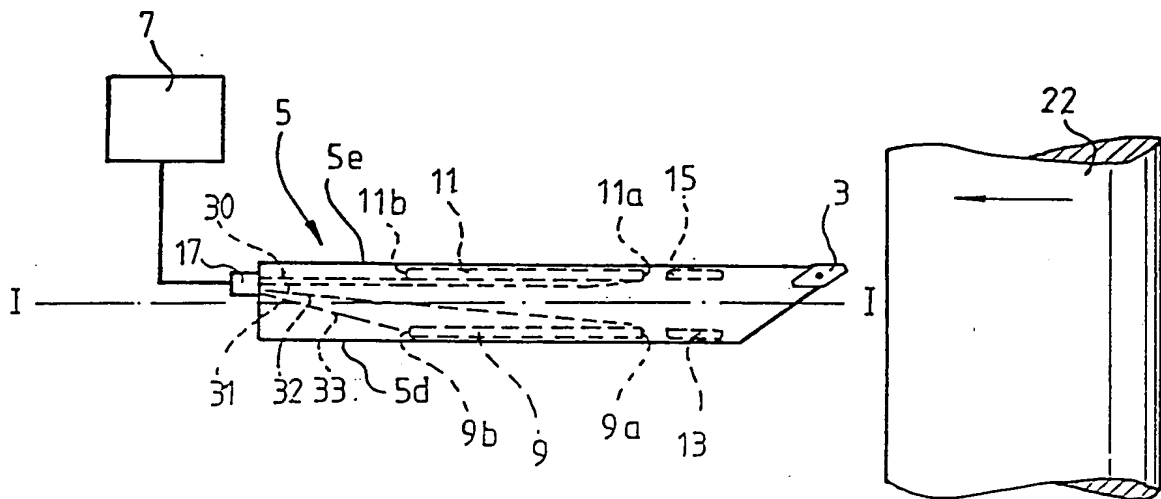


Fig. 3

METOD OCH ANORDNING FÖR STYRNING AV SVARVOPERATION

Tekniskt område

Föreliggande uppfinning avser en metod och en anordning för styrning av en svarvoperation, och närmare bestämt en metod, en anordning, en svarvverktygshållare och
5 en svarv för ökning av ytjämnheten hos en svarvad yta.

Bakgrundsteknik

När ett arbetsstycke bearbetas med hjälp av en svarv uppkommer alltid en viss ojämnheter i den svarvade ytan. Ojämnheten kan liknas vid ränder, eller gängor och upp-
10 kommer på grund av att det bearbetande verktygets skärande egg har en begränsad nosradie. Verktøygen tillverkas med flera olika standardradier. Eggens radie ger i kombination med matningen en yta som inte är helt slät. Låg matningshastighet ger förvisso en jämnare yta, men är
15 orationellt i industritillverkning och därför inte någon lösning på problemet.

Av rationalitetsskäl och kostnadsskäl vore mycket vunnit om man trots förhållandevis hög matningshastighet kunde åstadkomma en yta med så hög jämnhet att den efter-
20 bearbetning som idag ofta erfordras kan elimineras eller i vart fall reduceras avsevärt.

Sammanfattning av uppfinningen

Ändamålet med föreliggande uppfinning är att åstadkomma en metod och en anordning för ökning av ytjämnheten
25 vid svarvning.

Ändamålet uppnås med en anordning respektive en metod enligt patentkraven 1 respektive 12.

Kort beskrivning av ritningarna

Uppfinningen och ytterligare fördelar med den kommer
30 att beskrivas närmare nedan genom utföringsexempel under hänvisning till de åtföljande ritningarna, där:

fig 1 i en schematisk perspektivvy visar en utföringsform av anordningen enligt uppfinningen;

fig 2 i en schematisk perspektivvy visar en utföringsform av en skärhållare enligt uppfinningen; och fig 3 i en schematiskt vy ovanifrån visar anordningen enligt fig 1.

5 Beskrivning av en utföringsform

I fig 1 visas principiellt en utföringsform av anordningen, samt även av skärhållaren enligt uppfinningen. Hänvisningsbeteckningen 1 anger ett arbetsstycke som är uppsatt i en svarv och roterar i den riktning som visas av en pil P1. Arbetsstycket 1 bearbetas med ett verktyg 3, som benämnes skär, som är styvt förbundet med en verktygshållare 5, som benämnes skärhållare. Anordningen innefattar ett styrsystem med en styrenhet 7 och två aktuatorer 9, 11, varav den ena antyds med streckade linjer i fig 1 och båda visas i fig 2, som visar själva skärhållaren 5 i en annan vy.

Varje aktuator 9, 11 innefattar ett aktivt element 9, 11, vilket här utgörs av piezokeramelement. Ett piezokeramelement kan i sin tur vara utfört som en enhet eller med fördel vara uppbyggt som en så kallad stack och/eller av flera delement. Således kan elementet vara en solid kropp eller flera individuella men sammansatta och samverkande kroppar. De aktiva elementen 9, 11 är inbäddade i skärhållarens 5 kropp, som även benämnes skaft. Närmare bestämt är de ingjutna. Ingjutningen utförs genom att för varje aktivt element 9, 11 utformas en urtagning i verktygshållarens kropp, varefter det aktiva elementet 9, 11 placeras däri och gjuts över. Det aktiva elementet 25, 27 limmas företrädesvis mot urtagningens bottenyta. De aktiva elementen 9, 11 är inbäddade tämligen grunt, eller ytnära, i skärhållaren 5, dvs nära dess sidoytor 5d, 5e. Vidare är de aktiva elementen 9, 11 plattformiga och är parallellt, motstående anordnade. De aktiva elementen 9, 11 är därvid anordnade på var sin sida om skärhållarens 5 geometriska centrumaxel, vilken är markerad med I-I i fig 2. Ett aktivt element 9, 11 karaktäriseras av att det ändrar dimension när en elektrisk spänning anbringas över

det. Dimensionsförändringen står i ett förhållande till spänningen. Vidare är verktyget 3 monterat på hållarens 5 ovansida 5c.

5 Styrenheten 7 är via en ledning 15 och en kontakt 17 ansluten till skärhållaren 5. Inuti, dvs inbäddade i, skärhållaren 5 löper till/från kontakten 17 ledare 30-33 till de aktiva elementen, eller piezokeramelementen, 9, 11, se fig 3. Piezokeramelementen 9, 11 är långsträckta i skärhållarens 5 längdled och ledarna 30-33, som två och 10 två är anslutna till var sitt piezokeramelement 9, 11, är anslutna till deras framändar 11a respektive 9a och bakändar 11b respektive 9b.

Anordningen fungerar enligt följande. Verktyget 3 och skärhållaren 5 matas i riktningen av pilen P2 med en 15 viss matningshastighet M. Arbetsstycket roterar i pilens P1 riktning med en viss skärhastighet. Kombinationen av att $M > 0$, och verktygets 3 egg har en radie ger upphov till kvarstående, skruvformigt förlöpande åsar på den bearbetade ytan. Åsarna framstår närmast som ränder. Styr- 20 enheten 7 matar aktuatorerna och närmare bestämt piezokeramelementen 9, 11 med styrspänningar. När piezokeramelementen 9, 11 spänningssätts förlängs de således i högre eller mindre grad beroende på spänningarnas amplituder. Med andra ord erhåller varje piezokeramelement 9, 25 11 en dimensionsförändring i sin längdled, vilken även är skärhållarens 5 längdled. Piezokeramelementen 9, 11 är företrädesvis inbäddade i skärhållaren 5 så att deras begränsningsytor anliggar direkt mot materialet i skärhållarens 5 kropp. Piezokeramelementen 9, 11 har mot- 30 stående kraftförmedlande ytor i form av sina ändytor vid ändarna 9a, 9b, 11a och 11b. Dessa ändytor överför piezokeramelementens 9, 11 längdförändringar i skärhållarens 5 kropp. Eftersom piezokeramelementen 9, 11 är belägna på avstånd från verktygshållarens 5 centrumaxel I-I skapar 35 längdförändringarna vridande moment, vilka med den visade placeringen av piezokeramelementen 9, 11 yttrar sig som böjning. Med uttrycket "på avstånd från centrumaxeln"

- avses att piezokeramelementens 9, 11 geometriska centrumaxlar inte sammanfaller med skärhållarens 5 geometriska centrumaxel. Om centrumaxlarna skulle sammanfalla så skulle inget böjande moment åstadkommas utan enbart en
- 5 ren längdförändring av skärhållaren 23. Detsamma skulle gälla om båda piezokeramelementen 9, 11 skulle längdförändras i fas och lika mycket. De krafter som induceras med hjälp av piezokeramelementen 9, 11 böjer skärhållarens 5 framände 5a i sidled, från sida till sida, tack
- 10 vare att styrspänningarna till respektive piezokeramelement 9, 11 anbringas så att piezokeramelementen 9, 11 längdförändras i motfas mot varandra. Skärhållaren 5 bringas således att vibrationsartat röra sig omväxlande med och mot matningsriktningen.
- 15 De vridande momenten verkar således kring en axel som är vinkelrät mot centrumaxeln I-I och skapar en vibrationsrörelse i sidled, såsom anges med pilen P3. Genom sidovibrationerna breddas det spår som verktyget skapar i arbetsstyckets 1 yta och ränderna arbetas bort.
- 20 Styrspänningarnas utseende är dock av betydelse för resultatet. I ett föredraget utförande av anordningen alstrar styrenheten 7 sammansatta styrspänningar med ett brett, brusliknande frekvensinnehåll. En faktor i detta sammanhang är dock matningshastigheten M, som kan variera
- 25 tämligen kraftigt mellan olika svarvoperationer. Matningshastigheten har främst betydelse för styrspänningarnas amplitud. En föredragen utföringsform av anordningen enligt uppfinningen innefattar därför en styrenhet som är inställbar med avseende på styrspänningarnas amplitud.
- 30 Därigenom kan olika amplituder alstras.

Alternativa utföringsformer

- Ovanstående beskrivning utgör väsentligen ett ej begränsande exempel på hur anordningen enligt uppfinningen kan vara utformad. Många modifieringar är möjliga inom
- 35 ramen för uppfinningen såsom den definieras i de åtföljande patentkraven. Nedan följer några exempel på sådana modifieringar.

I en alternativ utföringsform innefattar styrenheten även ett organ för inställning av frekvensinnehållet i styrspänningarna.

5 I en annan alternativ utföringsform har styrenheten förinställda värden på frekvens och amplitud för styrspänningarna.

I ytterligare en alternativ utföringsform av anordningen enligt uppfinningen arbetar styrenheten 7 med återkopplad styrning, vilket innebär att den strävar
10 efter att ställa in vibrationernas amplitud på en lämplig nivå med hjälp av återkoppling från sensorer. Styrenheten 7 är valbar bland många olika typer, exempelvis analog återkopplad styrenhet, konventionell PID-regulator, adaptiv regulator eller någon annan lämplig typ av styrenhet.
15 För åstadkommande av nämnda återkopplade styrning är sensorer 13, 15 anordnade i skärhållaren 5, såsom åskådliggörs i figurerna. Sensorer 13, 15 är anordnade framför aktuatorerna 9, 11. Med framför avses närmre den ände av skärhållaren 5 där verktyget 3 är monterat, vilken ände
20 naturligt betraktas som skärhållarens 5 främre ände 5a. Motstående ände 5b är således skärhållarens 5 bakre ände. Sensorerna 13, 15 utgörs av piezoelektriska kristaller som alstrar en elektrisk spänning när de utsätts för kraftpåverkan. Sensorerna 13, 15 är företrädesvis, i lik-
25 het med aktuatorerna 9, 11 inbäddade i skärhållarens 5 kropp och är elektriskt förbundna med styrenheten 7 via ledare som är anslutna på motsvarande sätt som aktuatorernas ledare 30-33, men som av tydlighetsskäl ej visas.

Sensorerna 13, 15 utsätts för omväxlande drag- och
30 tryckkrafter. Varje sensor 13, 15 alstrar då en sensorspänning som varierar i takt med kraftvariationerna. Sensorspänningarna detekteras och analyseras av styrenheten 7, som styr aktuatorerna 9, 11 i enlighet med önskad amplitud hos sensorspänningarna. Den reglering som detta
35 innebär utförs med hjälp av en regleralgoritm. Det finns många kända regleralgoritmer att välja bland.

I ännu en alternativ utföringsform av anordningen enligt uppfinningen tar styrenheten hänsyn till vilken matningshastighet som är aktuell, dvs den har ett organ för angivelse av vilken matningshastighet som är aktuell
5 för den svarvoperation som skall påbörjas. I en NC-styrd svarv kan organet till och med automatiskt hämta denna information direkt från NC-styrssystemet.

En annan möjlig modifiering är att ändra antalet aktuatorer. I det enklaste fallet är en aktuator anordnad
10 i verktygshållaren. För att man skall uppnå en mer symmetrisk kraftpåverkan på verktygshållaren är det dock en fördel att anordna åtminstone det ovan beskrivna aktuatorparet med den beskrivna motstående placeringen. Det finns inget som hindrar att man anordnar fler aktuatorer,
15 som är parvis och motstående monterade i verktygshållaren. Av praktiska skäl och med tanke på produktionskostnader är det dock en nackdel att bädda in många aktuatorer.

Sättet att montera de aktiva elementen kan varieras.
20 Utöver ovannämnda monteringsätt kan de till exempel förmonteras i en gjutform i vilken verktygshållaren gjuts. Om de gjuts in i efterhand, såsom har beskrivits ovan kan de antingen täckas med samma material som verktygshållaren är tillverkat av eller något annat lämpligt material.
25 Vidare är alternativ till den ovan beskrivna, föredragna monteringen där elementen visserligen limmas mot urtagningens botten men två motstående kraftförmedlingsytor väsentligen alstrar de vridande momenten är andra alternativ möjliga. Ett sådant innebär att dimensionsförändringen helt överförs via limförbandet, vilket i princip
30 är möjligt med dagens mest hållfasta lim. I det fallet kan ovannämnda kraftförmedlingsytor anläggning utelämnas, vilket minskar kraven på passning. Även andra varianter ryms inom ramen för uppfinningen.

35 De aktiva elementen är formmässigt inte bundna till att vara rätblocksformiga och plattformiga som de visade elementen, utan formen kan variera. Plattformigheten är

dock en fördel, eftersom den bidrar till att minimera elementets volym. Vidare är långsträckthet en god form-egenskap som också bidrar till att elementet får en liten volym. Det är därvid att föredra att dimensionsförändringarna sker i elementets längdled.

Principiellt rymmer andra aktuator typer och -monteringar än de ovan beskrivna inom ramen för uppfinningen. Inbäddade, aktiva element uppvisar dock tydliga fördelar.

PATENTKRAV

1. Anordning för ökning av ytjämnheten hos en svar-
5 vad yta, vilken anordning innefattar ett styrsystem inne-
fattande en styrenhet (7) och en till styrenheten anslut-
bar och med en verktygshållare (5) förbindbar aktuator
(9, 11) k ä n n e t e c k n a d av att nämnda aktuator
är inrättad att bibringa verktygshållaren en vibrations-
10 rörelse i sidled.

2. Anordning enligt patentkrav 1, k ä n n e -
t e c k n a d av att nämnda aktuator (9, 11) innefattar
ett aktivt element (9, 11) som är inbäddbart i verktygs-
hållarens (5) kropp.

15 3. Anordning enligt patentkrav 1 eller 2,
k ä n n e t e c k n a d av att styrsystemet innefattar
en till styrenheten (7) anslutbar och med verktygshålla-
ren (5) förbindbar vibrationssensor (13, 15), att nämnda
vibrationssensor är anordnad för avkänning av verktygs-
20 hållarens vibrationer i sidled och att styrenheten är an-
ordnad för styrning av vibrationsrörelsen genom styrning
av aktuatoren i beroende av sensorsignaler från vibra-
tionssensorn.

4. Svarvverktygshållare, k ä n n e t e c k n a d
25 av att den innefattar en aktuator (9, 11), som är anord-
nad att bibringa svarvverktygshållaren (5) en vibrations-
rörelse i sidled.

5. Svarvverktygshållare enligt patentkrav 4,
k ä n n e t e c k n a d av att nämnda aktuator (9, 11)
30 innefattar ett aktivt element (9, 11), som är inbäddat i
svarvverktygshållarens (5) kropp.

6. Svarvverktygshållare enligt patentkrav 4 eller 5,
k ä n n e t e c k n a d av att den innefattar minst ett
par aktiva element, varvid de i paret ingående aktiva
35 elementen är motstående anordnade på var sin sida om
svarvverktygshållarens (5) centrumaxel.

7. Svarvverktygshållare enligt patentkrav 4, 5 eller 6, k ä n n e t e c k n a d av att den innefattar en vibrationssensor (13, 15), som är inbäddad i svarvverktygshållarens (5) kropp.

5 8. Svarv innefattande en verktygshållare (5) och en med verktygshållaren förbunden aktuator (9, 11), k ä n n e t e c k n a d av att aktuatoren är anordnad att bibringa verktygshållaren en vibrationsrörelse i sidled.

9. Svarv enligt patentkrav 8, k ä n n e t e c k -
10 n a d av att den innefattar ett styrsystem, varvid styrsystemet innefattar en styrenhet (7) och en till styrenheten ansluten och med verktygshållaren förbunden vibrationssensor (13, 15), att nämnda aktuator är ansluten till styrenheten, att nämnda vibrationssensor är anordnad
15 för avkänning av verktygets vibrationer i sidled och att styrenheten är anordnad för styrning av vibrationsrörelsen genom styrning av aktuatoren i beroende av sensorsignaler från vibrationssensorn.

10. Svarv enligt patentkrav 8 eller 9, k ä n n e -
20 t e c k n a d av att nämnda aktuator (9, 11) innefattar ett aktivt element (9, 11) som är inbäddat i verktygshållarens (5) kropp.

11. Svarv enligt patentkrav 10, k ä n n e t e c k -
25 n a d av att nämnda aktiva element (9, 11) utgörs av ett piezokeramelement (9, 11).

12. Metod för ökning av ytjämnheten hos en svarvad yta, innefattande att styra en verktygshållares vibrationer under svarvning, k ä n n e t e c k n a d av att bibringa verktygshållaren en vibrationsrörelse i sidled.

30 13. Metod enligt patentkrav 12, k ä n n e t e c k - n a d av att bibringa verktygshållaren nämnda vibrationsrörelse med hjälp av en aktuator innefattande ett i verktygshållarens kropp inbäddat aktivt element.

14. Metod enligt patentkrav 13, k ä n n e t e c k -
35 n a d av att återkopplat styra nämnda vibrationsrörelse genom att avkänna verktygshållarens sidovibration och styra nämnda aktuator i beroende av nämnda sidovibration.

15. Metod enligt något av patentkraven 12-14,
k ä n n e t e c k n a d av att anpassa nämnda vibra-
tionsrörelse med hänsyn tagen till matningshastigheten.

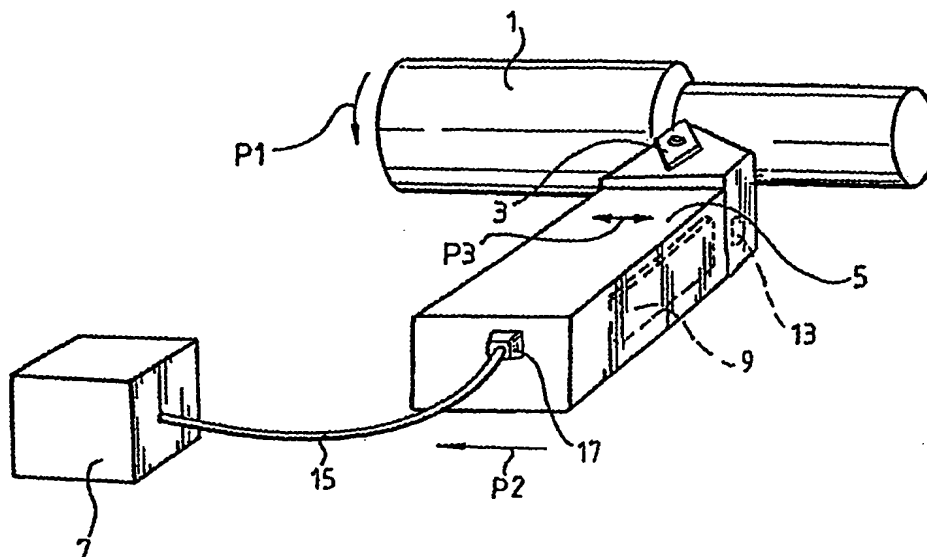
SAMMANDRAG

- Uppfinningen avser en anordning för ökning av yt-
5 jämnheten hos en svarvad yta, vilken anordning innefattar
ett styrsystem med en styrenhet (7) och en till styren-
heten anslutbar och med en verktygshållare (5) förbindbar
aktuator (9). Aktuators är inrättad att bibringa verk-
tygshållaren en vibrationsrörelse i sidled.
- 10 Uppfinningen avser även en metod för ökning av yt-
jämnheten hos en svarvad yta, innefattande att styra en
verktygshållares vibrationer under svarvning. Metoden
innefattar vidare att bibringa verktygshållaren en vib-
rationsrörelse i sidled.
- 15 Därtill avser uppfinningen en svarv respektive en
svarvverktygshållare som i likhet med anordningen är ut-
formade för att åstadkomma nämnda vibrationsrörelse i
sidled.
- 20
- 25
- 30 Publiceringsbild = Fig 1

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/SE99/01884</p> <p>(22) International Filing Date: 19 October 1999 (19.10.99)</p> <p>(30) Priority Data: 9803606-4 22 October 1998 (22.10.98) SE</p> <p>(71)(72) Applicants and Inventors: CLAESSON, Ingvar [SE/SE]; Hällestadsvägen 59, S-240 20 Dalby (SE); LAGÖ, Thomas [SE/SE]; Kristinedalsvägen 54, S-553 31 Jönköping (SE); HÅKANSSON, Lars [SE/SE]; Norra Hagtomsgatan 10, S-256 62 Helsingborg (SE).</p> <p>(74) Agent: AWAPATENT AB; P.O. Box 45086, S-104 30 Stockholm (SE).</p>		<p>(81) Designated States: AE, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), DM, EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published With international search report. In English translation (filed in Swedish).</p>

(54) Title: METHOD AND DEVICE FOR CONTROLLING A TURNING OPERATION



(57) Abstract

The invention relates to a device for increasing the surface smoothness of a turned surface, said device comprising a control system with a control unit (7) and an actuator (9) connectible to the control unit and connectible with a tool holder (5). The actuator is adapted to impart a vibrating motion in the lateral direction to the tool holder. The invention also relates to a method for increasing the surface smoothness of a turned surface, comprising the step of controlling the vibrations of the tool holder during turning. The method also comprises the step of imparting a vibrating motion in the lateral direction to the tool holder. Moreover, the invention relates to a turning lathe and a turning tool holder which like the device are designed to generate said vibrating motion in the lateral direction.

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METHOD AND DEVICE FOR CONTROLLING A TURNING OPERATIONField of the Invention

The present invention relates to a method and a device for controlling a turning operation, more specifically a method, a device, a turning tool holder and
5 a turning lathe for increasing the surface smoothness of a turned surface.

Background Art

When a workpiece is worked by means of a lathe, a certain degree of unevenness always arises in the turned surface. The unevenness can be resembled to stripes
10 or threads and arises owing to the cutting edge of the working tool having a limited nose radius. The tools are manufactured with a plurality of different standard radii. The radius of the cutting edge results, in combination with the feeding, in a surface which is not quite
15 smooth. A low feeding speed certainly gives a smoother surface but is irrational in industrial manufacture and therefore does not solve the problem.

For reasons of rationality and expense, much would
20 be gained if, in spite of a relatively high feeding speed, it would be possible to obtain a surface having such a high smoothness that the finishing which today is often necessary can be eliminated or, in any case, be significantly reduced.

Summary of the Invention

An object of the present invention is to provide a method and a device for increasing the surface smoothness in turning.

The object is achieved by a device and a method
30 according to claims 1 and 12, respectively.

Brief Description of the Drawings

The invention and further advantages thereof will now be described in more detail by way of embodiments with reference to the accompanying drawings, in which

Fig. 1 is a schematic perspective view of an embodiment of the inventive device;

Fig. 2 is a schematic view of an embodiment of a tool holder according to the invention; and

Fig. 3 is a schematic plan view of the device in Fig. 1.

Description of an Embodiment

Fig. 1 illustrates essentially an embodiment of the device and also of the tool holder according to the invention. Reference numeral 1 indicates a workpiece which is arranged in a lathe and rotates in the direction indicated by arrow P1. The workpiece 1 is worked by means of a tool 3, here referred to as insert, which is rigidly connected to a tool holder 5, here referred to as insert holder. The device comprises a control system with a control unit 7 and two actuators 9, 11, one of which is indicated by dashed lines in Fig. 1 and both of which are shown in Fig. 2, which illustrates the actual tool holder 5 in a different view.

Each actuator 9, 11 comprises an active element 9, 11, which here is a piezoceramic element. A piezoceramic element can in turn be designed as a unit or advantageously be made up as a so-called stack and/or of several partial elements. Thus the element can be a solid body or a plurality of individual, but composed and interacting bodies. The active elements 9, 11 are embedded in the body of the tool holder 5, which is also referred to as shaft. More specifically, they are fixed by casting. The casting is carried out by forming for each active element 9, 11 a recess in the body of the tool holder, whereupon the active element 9, 11 is placed therein and covered by casting. The active element 25, 27 is glued preferably to the bottom surface of the recess. The active elements 9, 11 are embedded fairly close to the surface of the tool holder 5, i.e. close to its lateral surfaces 5d, 5e. Moreover, the active elements 9, 11 are plate-shaped and are oppositely arranged in parallel.

The active elements 9, 11 are arranged on each side of the centre axis of the tool holder 5, said centre axis being designated I-I in Fig. 2. An active element 9, 11 is characterised in that it changes dimension when an electric voltage is applied across the same. The dimensional change is related to the voltage. Moreover, the tool 3 is mounted on the upper side 5c of the holder 5.

The control unit 7 is via a conduit 15 and a terminal 17 connected to the tool holder 5. Inside, i.e. embedded in, the tool holder 5 extend to/from the terminal 17 conductors 30-33 of the active elements, or the piezoceramic elements 9, 11, see Fig. 3. The piezoceramic elements 9, 11 are elongate in the longitudinal direction of the tool holder 5, and the conductors 30-33, which are connected in pairs to a piezoceramic element 9, 11 each, are connected to the front ends 11a, 9a and rear ends 11b, 9b thereof.

The device operates as follows. The tool 3 and the tool holder 5 are fed in the direction of arrow P2 at a certain feeding speed M. The workpiece rotates in the direction of arrow P1 at a certain cutting speed. The combination of $M > 0$, and the edge of the tool 3 having a radius causes remaining, helically extending ridges on the worked surface. More than anything, the ridges resemble stripes. The control unit 7 feeds control voltages to the actuators, more specifically to the piezoceramic elements 9, 11. When voltage is applied to the piezoceramic elements 9, 11, they are thus extended to a greater or smaller degree depending on the amplitudes of the voltages. In other words, each piezoceramic element 9, 11 obtains a dimensional change in its longitudinal direction, which also is the longitudinal direction of the tool holder 5. The piezoceramic elements 9, 11 are preferably embedded in the tool holder 5 so that their boundary surfaces abut directly against the material of the body of the tool holder 5. The piezoceramic elements 9, 11 have opposite power-transmitting surfaces in the

form of their end faces at the ends 9a, 9b, 11a and 11b. The end faces transfer the longitudinal changes of the piezoceramic elements 9, 11 in the body of the tool holder 5. Since the piezoceramic elements 9, 11 are spaced from the centre axis I-I of the tool holder 5, the longitudinal changes generate turning moments which in the illustrated arrangement of the piezoceramic elements 9, 11 show themselves as bending. By the expression "spaced from the centre axis" is meant that the centre axes of the piezoceramic elements 9, 11 do not coincide with the centre axis of the tool holder 5. If the centre axes should coincide, no bending moment would be obtained, but merely a pure longitudinal change of the tool holder 5. The same would apply if the two piezoceramic elements 9, 11 should be longitudinally changed concurrently and to the same extent. The forces induced by means of the piezoceramic elements 9, 11 bend the front end 5a of the tool holder 5 in the lateral direction, from side to side, thanks to the control voltages to the respective piezoceramic elements 9, 11 being applied so that the piezoceramic elements 9, 11 are longitudinally changed in opposition to each other. Thus the tool holder 5 is made to move in a vibrating manner alternately in and against the direction of feed.

The turning moments thus act about an axis which is perpendicular to the centre axis I-I and produce a vibrating motion in the lateral direction, as indicated by arrow P3. By the lateral vibrations, the groove which the tool forms in the surface of the workpiece 1 is widened and the stripes are worked off. The appearance of the control voltages, however, is important to the result. In a preferred embodiment of the device, the control unit 7 generates composite control voltages having a wide, noise-like frequency content. A factor in this context, however, is the feeding speed M which may vary quite considerably between different turning operations. The feeding speed is above all important to the amplitude

of the control voltages. A preferred embodiment of the inventive device therefore comprises a control unit which is adjustable in respect of the amplitude of the control voltages. As a result, different amplitudes can be generated.

Alternative Embodiments

The above specification essentially constitutes a non-limiting example of how the device according to the invention can be designed. Many modifications are possible within the scope of the invention as defined in the appended claims. Below follow some examples of such modifications.

In an alternative embodiment, the control unit also comprises a means for adjusting the frequency content of the control voltages.

In a further alternative embodiment, the control unit has preset values of frequency and amplitude of the control voltages.

In one more alternative embodiment of the inventive device, the control unit 7 operates with fed-back control, which means that it strives to set the amplitude of the vibrations at a suitable level by means of feedback from sensors. The control unit 7 can be selected among many different types, such as analog fed-back control unit, conventional PID regulator, adaptive regulator or some other suitable type of control unit. To achieve said fed-back control, the sensors 13, 15 are arranged in the tool holder 5 as illustrated in the Figures. The sensors 13, 15 are arranged in front of the actuators 9, 11. By "in front of" is meant closer to the end of the tool holder 5 where the tool 3 is mounted, said end being naturally considered the front end 5a of the tool holder 5. The opposite end 5b thus is the rear end of the tool holder 5. The sensors 13, 15 consist of piezoelectric crystals which generate an electric voltage when subjected to forces. The sensors 13, 15 are preferably, like the actuators 9, 11, embedded in the body of the tool holder

5 and are electrically connected with the control unit 7 via conductors which are connected in the same way as the conductors 30-33 of the actuators, but which for reasons of clarity are not shown.

5 The sensors 13, 15 are subjected to alternating pulling and pressing forces. Each sensor 13, 15 then generates a sensor voltage which varies concurrently with the variations in force. The sensor voltages are detected and analysed by the control unit 7, which controls the actuators 9, 11 in accordance with the desired amplitude of the sensor voltages. The regulation which this involves is carried out by means of a control algorithm. A large number of known control algorithms are available.

15 In one more alternative embodiment of the device according to the invention, the control unit takes the present feeding speed into consideration, i.e. the control unit has a means for indicating which feeding speed is appropriate for the turning operation which is to begin. In an NC-controlled lathe, the means can even automatically collect this information directly from the NC control system.

25 A further possible modification is to change the number of actuators. In the simplest case, one actuator is arranged in the tool holder. To achieve a more symmetric application of forces on the tool holder, it is however advantageous to arrange at least the above-described pair of actuators in the described opposite arrangement. There is nothing to prevent that a larger number of actuators are arranged which are oppositely arranged in pairs in the tool holder. For practical reasons and in view of the production costs, it is however disadvantageous to embed a large number of actuators.

35 The method of mounting the active elements may be varied. In addition to the above-mentioned way of mounting, they can be, for example, premounted in a mould in which the tool holder is cast. If they are fixed by cast-

ing later, as has been described above, they can either be covered with the same material as that of which the tool holder is made or with some other convenient material. Moreover it is possible to use alternatives to the above-described, preferred mounting, where the elements are certainly glued to the base of the recess but two opposite power-transmitting surfaces essentially generate the turning moments. Such an alternative means that the dimensional change is completely transferred via the glue joint, which in principle is possible with today's strongest adhesives. In that case, the abutment of the above-mentioned power-transmitting surfaces can be omitted, which reduces the claims for adaptation. Also other variants are contained within the scope of the invention.

The active elements are in respect of form not bound to be rectangularly parallelepipedal and plate-shaped as the shown elements, but the form may vary. The plate shape, however, is advantageous since it contributes to minimising the volume of the element. Moreover, an elongate form is an excellent property which also contributes to imparting to the element a small volume. It is preferred that the dimensional changes occur in the longitudinal direction of the element.

Basically, other types of actuators and ways of mounting than those described above are contained within the scope of the invention. However, embedded, active elements have obvious advantages.

CLAIMS

1. A device for increasing the surface smoothness
5 of a turned surface, said device comprising a control
system comprising a control unit (7) and an actuator (9,
11) connectible to the control unit and connectible with
a tool holder (5), characterised in that said
10 actuator is adapted to impart a vibrating motion in the
lateral direction to the tool holder.

2. A device as claimed in claim 1, characterised
15 in that said actuator (9, 11) comprises an
active element (9, 11) which is embeddable in the body of
the tool holder (5).

3. A device as claimed in claim 1 or 2, characterised
20 in that the control system comprises a
vibration sensor (13, 15) connectible to the control unit
(7) and connectible with the tool holder (5), that said
vibration sensor is adapted to detect vibrations of the
tool holder in the lateral direction, and that the control
unit is adapted to control the vibrating motion by
controlling the actuator according to sensor signals from
the vibration sensor.

4. A turning tool holder, characterised
25 in that it comprises an actuator (9, 11) which is adapted
to impart a vibrating motion in the lateral direction to
the turning tool holder (5).

5. A turning tool holder as claimed in claim 4,
characterised in that said actuator (9, 11)
30 comprises an active element (9, 11) which is embedded in
the body of the turning tool holder (5).

6. A turning tool holder as claimed in claim 4 or 5,
characterised in that it comprises at least
one pair of active elements, the active elements included
35 in the pair being oppositely arranged on each side of the
centre axis of the turning tool holder (5).

7. A turning tool holder as claimed in claim 4, 5 or 6, characterised in that it comprises a vibration sensor (13, 15) which is embedded in the body of the turning tool holder (5).

5 8. A turning lathe comprising a tool holder (5) and an actuator (9, 11) connected with the tool holder, characterised in that the actuator is adapted to impart a vibrating motion in the lateral direction to the tool holder.

10 9. A turning lathe as claimed in claim 8, characterised in that it comprises a control system, the control system comprising a control unit (7) and a vibration sensor (13, 15) connected to the control unit and connected with the tool holder, that said actuator
15 is connected to the control unit, that said vibration sensor is adapted to detect the vibrations of the tool in the lateral direction, and that the control unit is adapted to control the vibrating motion by controlling the actuator according to sensor signals from the vibration sensor.
20

10. A turning lathe as claimed in claim 8 or 9, characterised in that said actuator (9, 11) comprises an active element (9, 11) which is embedded in the body of the tool holder (5).

25 11. A turning lathe as claimed in claim 10, characterised in that said active element (9, 11) is a piezoceramic element (9, 11).

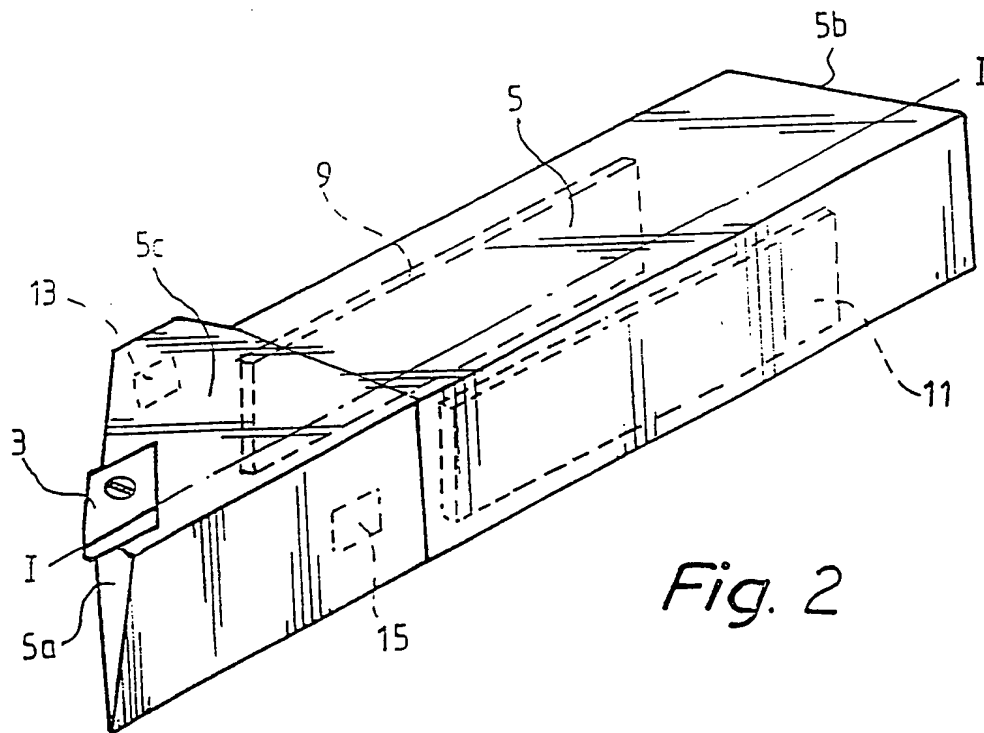
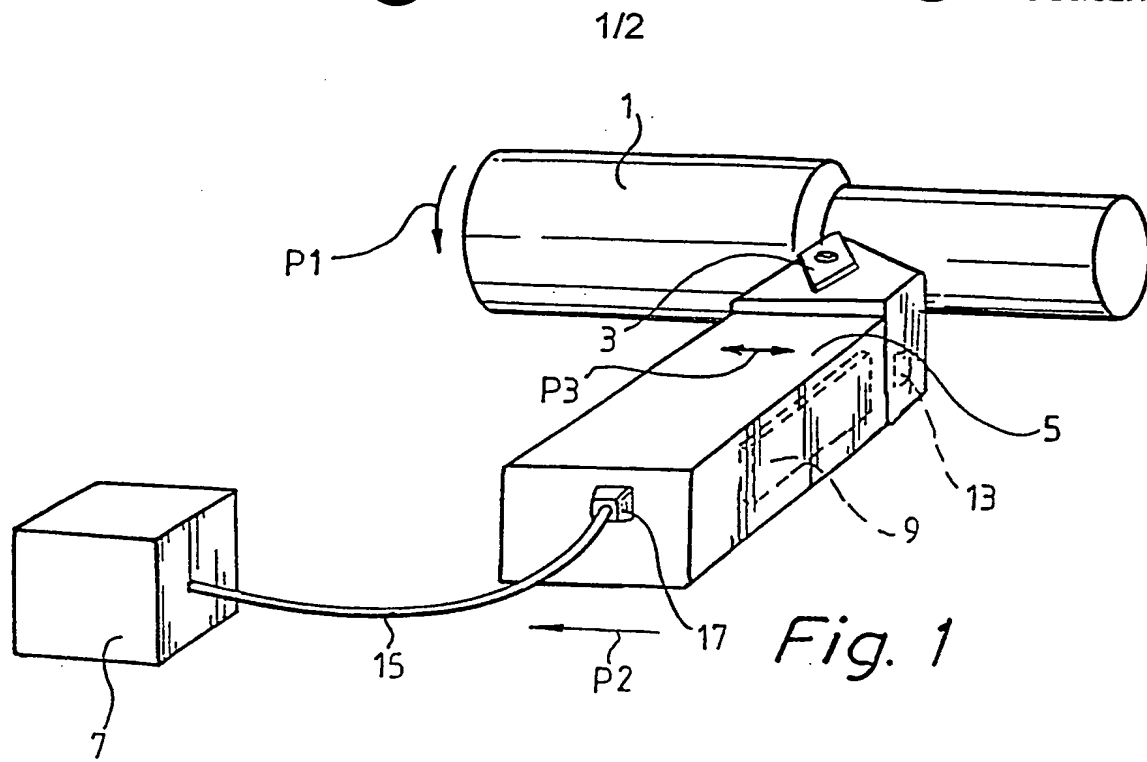
12. A method for increasing the surface smoothness of a turned surface, comprising the step of controlling
30 the vibrations of a tool holder during turning, characterised by the step of imparting a vibrating motion in the lateral direction to the tool holder.

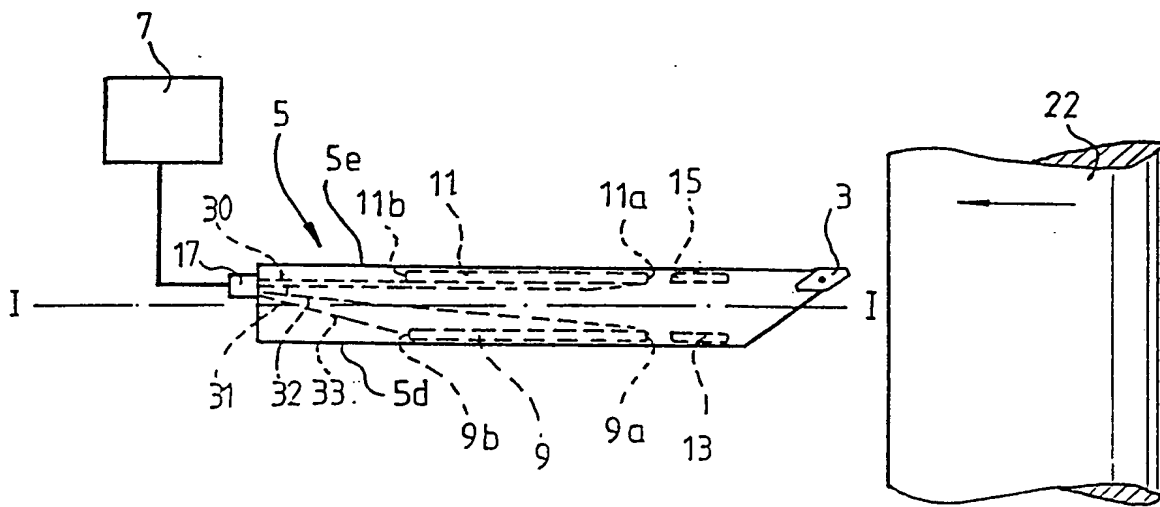
13. A method as claimed in claim 12, characterised
35 terised by the step of imparting to the tool holder said vibrating motion by means of an actuator comprising

an active element embedded in the body of the tool holder.

14. A method as claimed in claim 13, c h a r a c -
t e r i s e d by the step of controlling in a fed-back
5 manner said vibrating motion by detecting the lateral
vibration of the tool holder and controlling said actua-
tor according to said lateral vibration.

15. A method as claimed in any one of claims 12-14,
c h a r a c t e r i s e d by the step of adjusting said
10 vibrating motion to the feeding speed.



*Fig. 3*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 99/01884

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B23B 29/12, F16F 15/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B23B, B23C, B23Q, F16F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5170103 A (ROUCH ET AL), 8 December 1992 (08.12.92), column 4, line 26 - line 34; column 6, line 22 - line 45, figures 2,7, abstract	1-5,7-15
Y	--	6
Y	US 4849668 A (CRAWLEY ET AL), 18 July 1989 (18.07.89), column 5, line 20 - line 25, figure 4, abstract	6
X	Patent Abstracts of Japan, Vol 12, No 448, M-768 abstract of JP 63-180401 A (MITSU ENG & SHIPBUILD CO LTD), 25 July 1988 (25.07.88)	1-5,7-15
Y	--	6

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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International application No.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5558477 A (BROWNING ET AL), 24 Sept 1996 (24.09.96), figure 1, abstract	1-5,7-15
Y	--	6
A	US 5315203 A (BICOS), 24 May 1994 (24.05.94), figure 1, abstract -- -----	1-15

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SE 99/01884

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5170103 A	08/12/92	AU 655655 B AU 2183192 A CA 2097915 A DE 585400 T EP 0585400 A JP 6503042 T KR 121773 B WO 9220482 A	05/01/95 30/12/92 21/11/92 18/08/94 09/03/94 07/04/94 12/11/97 26/11/92
US 4849668 A	18/07/89	NONE	
US 5558477 A	24/09/96	EP 0715092 A JP 8234847 A	05/06/96 13/09/96
US 5315203 A	24/05/94	NONE	